Ion Beam Emittance from an ECRIS

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Simulation of ion beam extraction from an Electron Cyclotron Resonance Ion Source (ECRIS) is a fully 3 dimensional problem, even if the extraction geometry has cylindrical symmetry. To improve the magnetic confinement of such sources a multi-pole is added to the mirror field. Experimentally quadrupoles, hexapoles, and octupoles have been tried, however, in most cases a hexapole is used. This makes the extraction of a low emittance ion beam even more complicated because of coupling between the different planes of the six dimensional phase space by the magnetic field. Because of the strong magnetic flux density not only the electrons are strongly magnetized, but also the Larmor radius of ions is much smaller than the geometrical dimension ofthe plasma chamber. This has a strong influence on the behavior of charged particles within the plasma: the moveability of both, electrons and ions, is high in the direction of the magnetic field, but restricted in the perpendicular direction. This will influence several physical properties such as shielding, collision, and similar. If we assume that the influence of collisions is small on the path of particles, we can do particle tracking through the plasma if the initial coordinates of particles are known. We generated starting coordinates of ions by simulation of the electrons, accelerated by the 14.5 GHz rf-power fed to the plasma. For the simulation of the plasma electrons the TrapCAD code has been used, whereas for the ion tracking and diagnosis the KOBRA3 code was chosen. With that we were able to investigate the influence of different electron energies on the extracted ion beam. Using these assumptions we can reproduce the experimental results obtained 10 years ago, where we monitored the beam profile with the help of viewing targets. Especially the effect that different parts of the ion beam will be focused differently by a magnetic solenoid can be explained. Due to the coupling between different planes, simple projections of the six dimensional phase space into a 2D plane seems to be not very useful. The integration which is performed by doing a projection has to be replaced by a more differential presentation, namely to choose a slice of the full phase space. Methods have been developed to investigate arbitrary 2D cuts of the 6D phase space. The visualization of the simulation results is an important task. To this date we are able to discuss full 4D information. Currently, we extend our analysis tools towards 5D and 6D, respectively.